

REMARKS

Previously withdrawn claims 53-63, 65-87 and 109-116 are canceled along with claims 117-130.

Claims 27 and 95 have been amended.

Claims 1-52 and 88-108 will be pending in the application upon entry of this amendment.

I. Withdrawal of Previous Rejection

Applicant notes for the record that the Office has in the current Office action withdrawn the rejection of claims 1-52, 88-108 and 117-130 as obvious under 35 U.S.C. § 103(a) over Marino et al. in view of U.S. Patent No. 2,892,801 (Sargent) as set forth in the Office action dated January 4, 2008.

II. Rejection under 35 U.S.C. § 102(b)

Applicant requests reconsideration of the rejection of claims 1-3, 22-25, 95, 98, 101, 105-108, 117-119, 121, 124 and 127 under 35 U.S.C. § 102(b) as lacking novelty over the newly cited reference "Catalytic Production of Hydrogen from Methanol," *Catalysis Today*, 60 (2000), pp. 3-10 (de Wild et al.). Applicant submits that the pending claims are novel and patentable over de Wild et al.

Independent claims 1 and 117 (now canceled) are included in the rejection under 35 U.S.C. § 102(b), but independent claim 27 is not. However, claims 98, 101 and 105-108, which depend directly or indirectly from claim 27, are included in the novelty rejection. Since the Office action does not provide any explanation of the novelty rejection with respect to independent claim 27,¹ applicant believes that dependent claims 98, 101 and 105-108 were erroneously included in the rejection under 35

¹ In fact on page 4 of the Office action, it is acknowledged that de Wild et al. fail to teach reforming of ethanol as required by claim 27.

U.S.C. § 102(b). Presumably, these claims were intended to be included in one of the rejections under 35 U.S.C. § 103(a). Applicant requests clarification on the record.

Claim Interpretation and Product-by-Process Limitations

Contrary to the assertion at the bottom of page 2 of the Office action, claims 1, 88-90, 101, 106-108, 117-119 and 127 are not "drawn to methods for forming the catalyst." Applicant is not seeking protection for the reforming catalyst *per se* defined in terms of the process by which the catalyst is prepared. Rather, as previously pointed out by applicant, the pending claims are drawn to processes for reforming an alcohol, defined, at least in part, by the reforming catalyst contacted with the alcohol-containing feed gas mixture. The reforming catalyst used in the claimed process is in turn defined in part by one or more product-by-process limitations.

Moreover, the case authority cited on page 2 of the Office action does not stand for the proposition that the product-by-process limitations set forth in independent claim 1 can be ignored or not given patentable weight. The cited authority merely states that once a *prima facie* case under 35 U.S.C. § 102/103 has been established by the Office with respect to a product-by-process claim, the burden shifts to the applicant "to prove that the prior art products do not necessarily or inherently possess the characteristics of his claimed product." *In re Thorpe*, 227 USPQ 964, 966 (Fed. Cir. 1985).² In

² The affirmance by the Federal Circuit of the rejection of the product-by-process claims in *In re Thorpe* was not based on the finding that the Office properly ignored the product-by-process limitations, but the finding that the Office had correctly adduced a *prima facie* case that was not rebutted by the applicant. In *Thorpe*, the difference between the inventive process and the prior art was the addition of metal oxide and carboxylic acid as separate reagents instead of adding the more expensive, pre-reacted metal carboxylate. The process claims were deemed patentable. With respect to the corresponding

articulating a *prima face* case, "[t]he structure implied by the process steps should be considered when assessing the patentability of product-by-process claims over the prior art, especially . . . where the manufacturing process would be expected to impart distinctive structural characteristics to the final product." See MPEP § 2113, citing, *In re Garner*, 162 USPQ 221, 223 (CCPA 1979). That is, it is incumbent upon the Examiner to first provide a rationale tending to show that the claimed product appears to be the same or similar to that of the prior art, although produced by a different process. It is only then that the burden shifts to the applicant to come forward with evidence establishing an unobvious difference between the claimed product and the prior art product. See MPEP § 2113 citing *In re Marosi*, 218 USPQ 289, 292 (Fed Cir. 1983). Thus, while the Office's burden with respect to making out a *prima face* case under 35 U.S.C. § 102/103 with respect to product-by-process limitations may be lessened, such limitations cannot simply be ignored when first attempting to establish a *prima face* case of lack of novelty or obviousness.

Claims 4-6, 9-11, 33-35 and 39-41 are not "drawn to the method by which the surface area is measured" as stated on page 3 of the Office action. Again, as previously explained by the applicant, these dependent claims more particularly define the claimed alcohol reforming processes as recited in the independent claims by specifying surface area characteristics of

product-by-process claims, the Office was found to have met its initial burden based on (1) an "admission" in the application that the claimed product had properties "about equal" to those of the prior art; and (2) other evidence of record (the inventor's own notebook) in which the applicant postulated that his process was forming a metal carboxylate *in situ*. With a *prima facie* case established, Thorpe failed to meet his burden demonstrating that the prior art products did not possess the characteristics of the claimed product. In fact, Thorpe did not assert that the product of his process was different from the product of the prior art.

the reforming catalyst used in the process as determined by the well-known Brunauer-Emmett-Teller (BET) method. Since different surface area measuring techniques may result in different surface area determinations, it is appropriate for these claims to specify the method by which surface area is determined in order to adequately define this feature of the catalyst used in the claimed process. Nevertheless, as discussed in detail below, patentability of the dependent claims reciting surface area requirements is established by the elements of the principle independent claims.

The Pending Claims are Novel over de Wild et al.

In the newly cited reference, de Wild et al. disclose a process for reforming methanol to produce a hydrogen-containing gas. The catalyst used by de Wild et al. is structured in the same way as in a conventional automotive catalytic converter. In particular, the "catalytic structures" employed included a "commercial copper-based reforming catalyst" in the form of: (1) 3 mm pellets (used in a fixed bed); (2) a cylindrical aluminum foam wash-coated with a catalytic preparation incorporating the commercial catalyst; and (3) a similarly wash-coated aluminum heat exchanger (See Fig. 2 and Table 2). Wash-coats like those applied to the aluminum foam and heat exchanger substrates are typically prepared from suspensions (e.g., alumina sols) of commercial reforming catalysts (See de Wild et al. at page 9, first paragraph under Conclusions).³

Applicant respectfully submits that the commercial copper-based reforming catalyst referenced by de Wild et al. on page 5

³ This conventional wash-coating methodology is also referred to in de Wild et al. on page 5 in connection with the alternative of coating the "combustion compartment" of the aluminum heat exchanger with an **alumina-supported** platinum combustion catalyst to catalytically combust methanol or hydrogen off-gas from the fuel cell with air.

in the form of 3 mm pellets and wash-coats of commercial reforming catalysts are distinguished from the catalyst defined in claim 1. De Wild et al. do not disclose sufficient details of the copper-based pellet reforming catalyst to allow any meaningful comparison to the catalyst used in the claimed process, but it is likely a conventional Cu/ZnO/Al₂O₃ catalyst. The prior art is replete with descriptions of such copper-based, ceramic-supported reforming catalysts. For example, Marino et al., "Hydrogen from Steam Reforming of Ethanol Characterization and Performance of Copper-Nickel Supported Catalysts," *Int. J. Hydrogen Energy*, Vol. 23, No. 12, pp.1095-1101 (1998), which formed the basis of the now withdrawn obviousness rejection, report an investigation of the effects of copper loading and calcination reaction temperature on catalysts comprising copper and/or nickel supported on K-doped γ -Al₂O₃ spheres. In "Fuel Cell Grade Hydrogen from Methanol on a Commercial Cu/ZnO/Al₂O₃ Catalyst," *Applied Catalysis B. Environmental*, 38 (2002), pp. 259-269 (Choi et al.), the authors describe use of a Cu/ZnO/Al₂O₃ pellet (catalyst #EX-2248) manufactured and commercially available from Sud-Chemie in methanol reforming. Similar Cu-ZnO/Al₂O₃ commercial methanol reforming catalysts are described in "Fuel Cell Drive System with Hydrogen Generation Test," *Journal of Power Sources*, 86 (2000), pp. 228-236 (Emonts et al.). Copies of the Choi et al. and Emonts et al. references are included with the Supplemental Information Disclosure Statement submitted herewith. U.S. Patent Nos. 5,935,277 and 5,928,614 (Autenrieth et al.), referenced at paragraph [0069] of applicant's published specification (US 2004/137288 A1), also describe similar Cu/ZnO/Al₂O₃ pellet reforming catalysts.

By contrast, the reforming catalyst contacted with the alcohol-containing feed gas mixture in claim 1 comprises a metal

sponge supporting structure and a copper coating at least partially covering the surface of the metal sponge supporting structure. In particular, the metal sponge supporting structure is prepared by a process comprising leaching aluminum from an alloy comprising aluminum and a base metal (e.g., nickel, cobalt, copper). This description of the process by which the metal sponge supporting structure in claim 1 is made is a generic description of the method by which metal sponge supporting structures and similar materials (**commonly referred to and well-known to catalyst and process chemists as "Raney metals"**) are prepared as described, for example, in paragraphs [0038] - [0046] of applicant's published specification and the numerous references cited by applicant therein. In accordance with one preferred embodiment, the base metal of the alloy from which the sponge is made comprises nickel (e.g., see dependent claims 12 and 93). In such an embodiment, the nickel sponge supporting structure is prepared by leaching aluminum from a nickel-aluminum alloy using a leaching reagent (e.g., a caustic soda solution) to leave behind a distinct porous, sponge-like structure composed of interconnected nanometer-scale nickel particles. Metal sponges comprising other base metals are prepared in a similar manner and possess similar structural characteristics.

As previously noted by applicant, it has been found in accordance with the claimed invention that catalysts comprising copper at the surface of a Raney metal sponge supporting structure exhibit the mechanical strength, high surface area, high thermal conductivity, and density of the sponge supporting structure combined with the desired catalytic activity of the copper such that it is particularly suited for gas-phase reforming of alcohols.

The Raney manufacturing process imparts distinctive structural characteristics to the metal sponge and reforming catalyst used in the process of claim 1 that must be accounted for by the Office in attempting to establish a *prima facie* case of lack of novelty. Applicant submits that with respect to the product-by-process limitations in claim 1, the Office has failed to provide any rationale whatsoever showing that the catalyst prepared in accordance with and utilized in the claimed alcohol reforming process appears to be the same or similar to that described by de Wild et al. In particular, it is applicant's understanding that in the rejection of claim 1 as lacking novelty over de Wild et al., it is the Examiner's contention that the requirement of metal sponge supporting structure is satisfied by the catalytic structure comprising a cylindrical aluminum foam. However, those skilled in the art readily recognize that the aluminum foam shown in Fig. 2 of the cited reference is distinct from a Raney metal sponge supporting structure prepared by a process comprising leaching aluminum from an alloy comprising aluminum and a base metal.

Although few details are provided by de Wild et al., aluminum foams are conventionally made by mixing aluminum powder with a gas-forming or releasing agent, compacting the mixture into a precursor and placing the precursor into a mold of the desired shape of the final product. The mold is then heated to decompose the gas-forming agent and release a gas that forms bubbles in the aluminum metal. The precursor expands and takes the shape of the mold and is then cooled off, so that the resulting aluminum foam is frozen in the desired shape. The process produces a macroporous aluminum foam structure (See the aluminum foam cylinder in Fig. 2 of de Wild et al.). Aluminum is not lost or leached and the aluminum foam would not contain a

"base metal." Furthermore, the macroporous structure of the foam is formed by gas bubbles and is manifestly different from the interconnected nanometer-scale metal particles of a Raney metal sponge produced by the loss of the leached aluminum.

In the absence of any explanation by the office showing that the claimed catalyst and Raney metal sponge supporting structure is the same or similar to that of the wash-coated foamed aluminum substrate, claim 1 is submitted as novel over de Wild et al. That is, in the absence of having properly considered the Raney structure implied by the process steps recited in claim 1, particularly where the manufacturing process would ne expected to impart distinctive structural characteristics to the supporting structure, the product-by-process limitations in claim 1 cannot be disregarded and a *prima face* case under 35 U.S.C. § 102 has not been established.

Applicant further submits that the alcohol reforming process defined in claim 1 is novel and patentable over the disclosure in de Wild et al. independent of the claimed process steps defining the manner by which the metal sponge support of the reforming catalyst is prepared.

As noted above, the catalyst used in the process of claim 1 comprises a metal sponge supporting structure and a copper coating at least partially covering the surface of the metal sponge supporting structure. Applicant submits that the Cu/ZnO/Al₂O₃ pellets of de Wild et al. and the wash-coated substrates prepared using suspensions of commercial reforming catalysts, fail to provide a catalyst having a copper coating at least partially covering the surface of a metal sponge supporting structure. Instead, the copper contained in the catalytic structures of de Wild et al. is supported on a metal oxide ceramic such as alumina and/or zirconia and does not

partially cover the surface of the metal sponge supporting structure.

In view of the above, independent claim 1 and claims 2, 3, 22-25 and 95 depending therefrom are submitted as novel over the disclosure in de Wild et al.

Claim 95 has been amended to depend from claim 94 requiring that the feed gas mixture comprise ethanol. Applicant notes that the assertion on page 4 of the office action that the methanol reforming process of de Wild et al. would inherently produce methane in the reforming product mixture as called for in claims 95 and 98 is erroneous.

III. Rejections under 35 U.S.C. § 103(a)

Claims 27, 28, 32, 38, 51, 88-90, 94, 122 and 123

Applicant requests reconsideration of the rejection of claims 27, 28, 32, 38, 51, 88-90, 94, 122 and 123 under 35 U.S.C. § 103(a) as obvious over de Wild et al.

Independent claim 27 is directed to a process for reforming ethanol. The process of claim 27 comprises contacting a feed gas mixture comprising ethanol with a reforming catalyst at a temperature below about 400°C to produce a reforming product mixture comprising hydrogen. The reforming catalyst contacted with the feed gas mixture in claim 27 as amended comprises copper on the surface of a metal supporting structure. The catalysts used in the practice of the present invention are stable in and particularly active for the gas-phase, thermal decomposition of ethanol into hydrogen, methane, carbon dioxide, and carbon monoxide at moderate temperatures.

The catalytic structures used in the methanol reforming process in de Wild et al. include Cu/ZnO/Al₂O₃ pellets and the

wash-coated substrates prepared using commercial reforming catalysts. These structures fail to provide a catalyst having copper on the surface of a metal supporting structure. To the extent that the aluminum foam or heat exchanger substrates are considered metal supports, copper in the wash-coat is on a metal oxide ceramic such as alumina and/or zirconia either as the core of the pellet and/or as a component of the wash-coat applied to the aluminum foam or heat exchanger substrates. Nothing in the disclosure of de Wild et al. teaches or suggests modifying the Cu/ZnO/Al₂O₃ pellets or the wash-coated substrates prepared using commercial reforming catalysts to obtain a catalytic structure in which the active copper is on the surface of a metal supporting structure.

In view of the above, claim 27 and claims 28, 32, 38 and 51, which depend directly from claim 27, are submitted as patentable over the disclosure in de Wild et al.

Claims 88-90 and 94 depend directly or indirectly from claim 1 and are submitted as patentable over de Wild et al. for the reasons set forth above with respect to claim 1 in response to the rejection under 35 U.S.C. § 102(b) and for the further limitations set forth in these claims.

Claims 7, 8, 12-21, 26, 29-31, 36, 37, 42-50, 52, 91-93 and 102-104

Applicant requests reconsideration of the rejection of Claims 7, 8, 12-21, 26, 29-31, 36, 37, 42-50, 52, 91-93 and 102-104 under 35 U.S.C. § 103(a) as obvious over de Wild et al. in further view of Sargent.

The Office acknowledges that the catalytic structures of de Wild et al. do not contain a metal supporting structure comprising nickel.

The disclosure in Sargent has been discussed extensively by the applicant in response to previous Office actions.

In an obviousness inquiry there must be a reason for one skilled in the art to modify and/or combine the elements of the prior art in a particular manner that would yield the claimed invention, *KSR International Co. v. Teleflex Inc.* 550 U.S. ___, ___, 82 USPQ2d 1385, 1395 (2007). On page 6 of the Office action, the Office attempts to articulate a motivation for one skilled in the art to use the copper-plated nickel sponge of Sargent as the catalyst in the alcohol reforming reaction of de Wild et al. by noting, "since it has high activity."

Applicant respectfully submits that this attempt by the Office falls far short of the standard necessary to establish a *prima facie* case of obviousness and begs the question: "active for what?"

In Sargent, catalysts with various copper loadings were characterized by the activity of the catalyst toward the liquid-phase hydrogenation of glucose to sorbitol. Based on the results in Example 7, Sargent observes that "the catalysts of the present invention are at least three times as effective as commercial Raney nickel in these hydrogenation reactions."

The skilled person would not look to the copper-plated nickel sponge of Sargent as a substitute for the Cu/ZnO/Al₂O₃ pellets or wash-coated substrates used to reform methanol in de Wild et al. The alcohol reforming processes of the present invention and de Wild et al. require contacting a feed **gas** mixture comprising the alcohol to be reformed with the reforming catalyst. Sargent fails to teach or suggest that the catalyst he discloses is suitable for any **gas-phase** reaction, and particularly, the **gas-phase dehydrogenation of an alcohol** as called for in the pending claims. Rather, the reactions

actually demonstrated by Sargent are all **hydrogenation** reactions and are conducted in the **liquid-phase**. While Sargent makes passing reference to suitability of the catalysts described therein for "**certain** dehydrogenation, dehalogenation and desulfurization reactions," nothing in the reference suggests to one skilled in the art that gas-phase reforming of alcohols is among the certain dehydrogenation reactions for which the catalyst might be suitable. The skilled person would not reasonably extrapolate the success reported by Sargent for liquid-phase hydrogenation of glucose to sorbitol as suggesting that whole-sale substitution of Sargent's copper-plated nickel sponge for the Cu/ZnO/Al₂O₃ pellets or wash-coated substrates of de Wild et al. would provide a suitable catalyst for the gas-phase reforming of methanol.

In view of the above, applicant submits that the Office has failed to establish a *prima facie* case of obviousness with respect to the invention as defined in dependent claims 7, 8, 12-21, 26, 29-31, 36, 37, 42-50, 52, 91-93 and 102-104 based on the disclosure in de Wild et al. and Sargent.

Claims 4-6, 9-11, 33-35 and 39-41

Applicant requests reconsideration of the rejection of claims under 4-6, 9-11, 33-35 and 39-41 under 35 U.S.C. § 103(a) as obvious over de Wild et al. in further view of Marino et al.

Claims 4-6, 9-11, 33-35 and 39-41 depend directly or indirectly from claims 1 or 27. The above-noted deficiencies with respect to the primary reference can not be overcome by resort to Marino et al. Accordingly, claims 4-6, 9-11, 33-35 and 39-41 are submitted as patentable over the cited references for the reasons set forth above with respect to the principal

independent claims from which they depend and for the further limitations set forth in these claims.

Claims 96, 97, 99, 100, 125 and 126

Applicant requests reconsideration of the rejection of claims 96, 97, 99, 100, 125 and 126 under 35 U.S.C. § 103(a) as obvious over de Wild et al. in further view of U.S. Patent No. 4,086,877 (Henkel et al.).

Claims 96, 97, 99 and 100 depend directly or indirectly from claims 1 or 27. Claims 125 and 126 have been canceled. The above-noted deficiencies with respect to the primary reference can not be overcome by resort to Henkel et al. Accordingly, claims 96, 97, 99 and 100 are submitted as patentable over the cited references for the reasons set forth above with respect to the principal independent claims from which they depend and for the further limitations set forth in these claims.

Favorable reconsideration and allowance of all pending claims are requested.

The Commissioner is hereby authorized to charge the fee for a three month extension of time up to and including February 6, 2009, and any other fees in connection with this response, to Deposit Account No. 19-1345.

Respectfully submitted,

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